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Seasonal Variation in the Rate of Growth of Pre-school Children

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CONTENTS

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SEASONAL VARIATION IN THE RATE OF GROWTH OF PRE-SCHOOL CHILDREN

HUGHINA McKAY AND MARY ANN BROWN

The purpose of this study was to collect, tabulate, and analyze data relative to the growth of pre-school children. It was hoped that the results might be helpful in determining whether or not there is a seasonal variation in the rate of growth of pre-school children, and, if so, whether it is due to seasons alone or whether there may be other factors, either controllable or uncontrollable.

Investigation of the periodic rates of gain due to seasons dates back to 1883 when Malling-Hansen began a study of a group of boys in the Deaf and Dumb Institute in Copenhagen (16). The group consisted of 70 boys between the ages of 9 and 15 years, who were weighed and measured four times a day over a period of 3 years with the exception of the summer vacation period. The boys were not weighed individually but in groups of sixteen to eighteen.

As a result of these observations Malling-Hansen reported variations in the rate of growth during the different seasons. The period of greatest gain occurred in August, September, and October. An arrest in the increase in weight or loss of weight occurred from the first of May to the middle of July. Environmental factors, such as food and activities, as well as seasonal temperature, were considered causes of the variations in weight increases.

Since 1883, several investigators have reported results of observations on different age groups and in different climates. Bleyer (3) made a study of infants in St. Louis and reported that children under one year of age made their greatest gain during August and September. Faber (6), interested in the factor of climate, made a similar study in San Francisco but found irregular fluctuations in growth. Gebhart (8), working with the Association for the Improvement of the Condition of the Poor in New York City, made a study among the Italian children of school age in that city and found a greater gain in the fall, with a delay or arrest of weight in the spring months. Holt and Fales (10) observed a group of children in an institution and, because of the sameness of

environment and the slight seasonal changes in diet, eliminated many of the variable factors that might have influenced the rate of growth. In their summary they state:

> "While these observations are not numerous, they were continued long enough to show very clearly that in this group there were no regular seasonal variations. This is especially significant since the living conditions were so nearly uniform throughout the year. The annual rate of gain was remarkably regular, though the monthly gains showed wide fluctuations, with no regularity whatever. This emphasizes the necessity of prolonged observations before a stationary weight can be considered significant."

Porter (23, 24), working in Boston, made a very valuable contribution to the information available concerning variations in the rate of growth. Of particular value was the emphasis he placed on the necessity of grouping children according to the months of the year in which they were weighed rather than in groups of the same age in months.

Emerson (5) reported a study made on 833 children in Honolulu, New York, and Toronto in 1927. He concluded that:

> "Variations in the rate of gain in weight of children from 5 to 10 years of age are commonly observed, the rate of gain being commonly greater during the months when school vacations and favorable climatic conditions permit the nearest approach to good hygienic conditions for children, and when the incidence of acute infections affecting children is at its lowest.
>
> "There does not appear to be any evidence to justify considering these seasonal variations of gains in weight as a normal biologic phenomenon for healthy children under favorable conditions of environment.
>
> "Among the possible determining factors of the variations in the rate of gain in weight of children of school age in Honolulu, Toronto, and New York City, the incidence of infections, particularly those acquired through the respiratory tract, is believed to be of much importance.
>
> "Seasonal or periodic variation in weight accretion of children is probably an accidental phenomenon, not necessary or euthenic in character, but an expression of unfavorable conditions affecting the child.
>
> "A child who fails to gain in weight each month, at least up to the age of 10 years, is in all probability suffering from some form of infection or fatigue in which diet, housing, and school attendance may play important contributing parts.
>
> "Groups of children living under favorable conditions can be found who, in the absence of infections or other sicknesses exhibit a regular monthly gain in weight regardless of the season of the year."

Orel (21) reported an increase in weight in October and November and a relatively low rate of growth in June and July among children being treated for mild tuberculosis. He accounted for this seasonal change by the increased water output in summer which is not covered by a sufficient intake and to the relative infrequency of disease in the autumn.

Recently, a study has been made in a state institution in Kansas among healthy children from 5 to 11 years of age. These children were divided into three groups. One group, designated as the orange group, received daily the equivalent of two oranges. A second group, known as the light group, received irradiation from an Alpine lamp. The third group served as controls and had no addition to the regular routine diet of the school. The results are summarized in the fifth biennial report of the director of the Kansas Agricultural Experiment Station (12). They are as follows:

> "1. Seasonal variation in growth occurred in all groups of children. Growth was more rapid in the fall months than in the months of January and February.
> "2. The gain during the spring months of 1928-1929 was greater than during the spring of the past two years, and there were fewer months in which there was a loss of weight. It is thought that this may be due to the fact that the light and orange treatments were begun early in the fall of 1928, whereas in previous years the treatments were begun at or after the depression period had begun."

In 1930, Orr and Clark (22) reported a study of the growth of 657 children from 7 to 11 years of age in four towns in Scotland. The children were weighed and measured in quarterly periods, beginning the second week in December 1928. Orr and Clark found a significant difference in the increase in both height and weight among the four periods. There was a much greater increase in height in the 3 months from the end of March to the end of June than in any other period. The smallest increase in height was in the months of October, November, and December. Greatest weight increases were made during the quarter July, August, and September, with the second greatest increase in the quarter October, November, and December.

Corry Mann (17) observed a seasonal variation in growth in both height and weight among a group of 220 school boys. There was a greater growth in both height and weight from April first to October first than during the remainder of the year.

Further reference will be made to the findings of these various workers.

PROCEDURE

The study herein reported was started in January 1927 and concluded in October 1930. The first 4 months served as a preliminary period for the development of technique. The periods which will be termed the first, second, and third years in this report extended from May 1927 to May 1928, from May 1928 to May 1929, and from October 1929 to October 1930, respectively.

Children included in the study.—Normal healthy children were selected for the study. All had been examined by a pediatrician and were in good physical condition. Although the study was planned to include pre-school children only, a fairly large group of children aged five to six, as well as a few older children, have been included. Table 1 shows the age distribution of the children.

TABLE 1.—Age Distribution of Ohio Children Studied

3-year period	2-3 years	3-4 years	4-5 years	5-6 years	6-7 years	7-8 years
Girls	6	15	34	25	4	1
Boys	12	19	26	23	6	2

The entire group of children studied may be divided into two distinct groups. One group, much the larger one, came from homes in which the parents were in moderately comfortable circumstances and were distinctly above the average in education and in intelligence. Many of the fathers were professional men, the majority of the mothers were college graduates, and a few of the mothers were also professional women. Many of the children of this group attended nursery schools, two of which are maintained in connection with The Ohio State University. Children from this group will be referred to in this report as Group I.

The children of the other group, much smaller in number, were from families of a somewhat lower economic level. In the main, environmental conditions for this group were somewhat less favorable than for Group I.

The children of both groups, however, were well cared for. Modern practices in regard to diet, to hours of rest, out-of-door play, and frequent medical examinations were followed, in the main, for both groups.

COLLECTION OF DATA

For weighing the children, a tested scale was used. Recumbent lengths were obtained by use of a standard which was graduated to eighths of inches and which had a stationary piece at one end and a movable one at the other.

During the early part of the 3-year period, with the exception of one month, both writers worked together in weighing and measuring the children, one checking the other. Later in the study, one of the writers, with the aid of graduate assistants, did the weighing and measuring. All children were weighed in ordinary indoor clothing without shoes or sweaters. Recumbent lengths were taken with the children in stocking feet.

The variations due to change of clothing have been studied by Gebhart, who reports that this factor cannot account for the drop in weight in the early spring and for the rise during the summer and early fall, which he noted. The results of his observations due to change of clothing are given in Table 2.

Such changes in weight as have been observed among the Ohio children studied certainly cannot be accounted for by this factor.

TABLE 2.—Comparison of the Average Weight of Clothing for the Summer and Winter Months*

Age	Boys				Girls			
	Cases	Average weight summer clothing	Cases	Average weight winter clothing	Cases	Average weight summer clothing	Cases	Average weight winter clothing
	No.	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*	*No.*	*Lb.*
1-4.....	32	1.3	251	1.9	31	1.1	241	1.6
1-8.....	14	2.2	159	2.4	24	1.5	156	2.1

*From Gebhart's work with Italian children in New York City (4).

Monthly weighings and measurings were made at approximately the same time of day each month to avoid, as far as possible, the fluctuations in weight which may occur during any one day. As far as possible, measurements were made on the same day of the month each time.

During the first year, measurements were made each month. When, because of his illness or because of his absence from the city, it was necessary to omit measuring a child for a month or longer, his gains or losses in weight for the period were divided equally among the months omitted.

During the second and third years, weighing and measuring were omitted during the period from June to October. The gains or losses of the children during these summer months were then divided equally among the months omitted; for example, child number 16, who was not weighed during the summer months, showed a gain of 1.44 pounds when she was weighed in October. This gain was divided equally into four monthly gains of 0.36 pound each.

Number of children included in the study.—Monthly records for varying lengths of time were obtained for the different children observed during the 3 years. During the period, 173 records were obtained. Twenty-three children were weighed and measured for 2 years at monthly intervals, except during the summer. For 68

other children monthly records were obtained for one year, making a total of 114 records that are complete for one year. For 59 other children, records were obtained for periods varying from 2 to 11 months.

The results of this study will be reported, therefore, as for a group of 114 children when reference is made to yearly gains or losses and as for a group of 173 when reference is made to monthly gains or losses.

FACTORS WHICH MAY INFLUENCE THE RATE OF GROWTH OF CHILDREN

Food habits.—It was manifestly impossible to make a quantitative study of the food intake of such a large group of children for the period during which they were observed. Much significant information concerning their food habits was obtained however.

Through personal interviews with the parents, through records of food intake, and through answers to questionnaires, a fairly clear picture of the food habits of each child was obtained. A number of the children had been included in a weighed dietary study made during an earlier year (13).

Health habits.—Information concerning the hours of sleep at night, the length of day-time nap, and the time spent out-of-doors daily were also obtained through the use of questionnaires answered by the parents.

Illnesses.—At the time of the monthly weighings the mother reported the kind, intensity, and duration of any illness which the child had had during the month.

Weather conditions.—A monthly meteorological report including temperature, humidity, amount of rainfall, and hours of sunshine was obtained each month from the United States Department of Agriculture Weather Bureau, Columbus, Ohio.

FINDINGS OF THE STUDY

WEIGHT

Average monthly gains in weight were calculated for all children for whom records for 2 or more months were obtained during the 3-year period. These averages for boys, for girls, and for both sexes for each of the 3 years, as well as for the entire period, are recorded in Table 3.

TABLE 3.—Average Monthly Gains of 173 Ohio Children

	May		June		July		August		September		October		November		December		January		February		March		April		Total
	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	Cases No.	Av. gain Lb.	
Entire group																									
1927–28...	44	0.29	44	0.36	44	0.15	44	0.92	44	0.39	44	0.75	44	0.20	44	0.66	44	0.16	44	0.46	44	-0.03	44	0.02	4.33
1928–29...	30	0.65	30	0.49	30	0.50	30	0.50	30	0.50	36	0.74	36	0.72	36	-0.03	36	0.95	35	0.49	34	0.32	30	0.18	6.01
1929–30...	73	0.34	62	0.35	60	0.47	60	0.47	60	0.47	74	0.70	75	0.46	69	0.33	67	0.16	71	0.46	71	0.38	71	0.01	4.60
1927–30...	147	0.39	136	0.39	134	0.37	134	0.62	134	0.45	154	0.72	155	0.45	149	0.34	147	0.35	150	0.47	149	0.24	145	0.05	4.84
Boys																									
1927–28...	22	0.43	22	0.30	22	0.16	22	1.27	22	0.12	22	0.86	22	0.19	22	0.56	22	0.08	22	0.44	22	-0.09	22	-0.15	4.17
1928–29...	17	0.68	17	0.51	17	0.52	17	0.52	17	0.52	18	0.62	18	0.69	18	0.20	18	0.93	18	0.31	17	0.42	15	-0.10	5.82
1929–30...	38	0.45	30	0.38	30	0.50	30	0.50	30	0.50	40	0.70	40	0.66	39	0.33	40	0.22	40	0.47	39	0.38	38	0.04	5.13
1927–30...	77	0.50	69	0.39	69	0.40	69	0.75	69	0.38	80	0.73	80	0.54	79	0.36	80	0.34	80	0.43	68	0.26	65	-0.04	5.04
Girls																									
1927–28...	22	0.14	22	0.44	22	0.14	22	0.56	22	0.67	22	0.64	22	0.21	22	0.75	22	0.24	22	0.49	22	0.03	22	0.19	4.50
1928–29...	13	0.62	13	0.47	13	0.47	13	0.47	13	0.47	18	0.85	18	0.75	18	-0.26	18	0.96	17	0.68	17	0.22	15	0.47	6.17
1929–30...	35	0.22	32	0.32	30	0.43	30	0.44	30	0.44	34	0.70	35	0.24	30	0.34	27	0.06	31	0.44	32	0.37	33	-0.02	3.98
1927–30...	70	0.27	67	0.39	65	0.34	65	0.48	65	0.52	74	0.72	75	0.36	70	0.31	67	0.36	70	0.52	71	0.23	70	0.15	4.65

As shown by this table the early spring months, March and April, seem especially unfavorable to growth. With the exception of December 1928, the average gains in weight were lower for April and March than for any of the other months.

Contrasted with these low average increases in weight for the early spring months are the much larger gains for October.

The same tendency is noted when the sexes are considered separately; that is, both boys and girls showed an acceleration in growth in the fall months and a retardation in the spring months.

For the purpose of this study the year was arbitrarily divided into two seasons, summer and winter—the months of May to October, inclusive, being termed the summer season, and November to April, inclusive, the winter season. The monthly, average gain in weight was calculated for each season. The results show a greater gain during the summer season than during the winter season for each of the 3 years. (See Table 4).

For the first year, the average gain per month during the summer season was twice that of the winter season, 0.48 pound per month as compared to 0.24 pound. In other words, 67 per cent of the total yearly gain was made during the 6 months, May to October, inclusive.

For the second year, the gain during the summer season was 0.56 pound per month as compared to 0.44 pound during the winter season, or 56 per cent of the total for the year.

The same tendency toward greater growth in the summer season was also evident during the third year, for which the average monthly gain during the summer months was 0.47 pound as compared to 0.30 pound for the winter months, or 61 per cent of the total.

Not only was the total annual increment in weight greater during the summer than during the winter season, but the number of children who made their greatest gain during the summer season was large. Eighty-five children made their greatest gain during the summer season as compared to 29 children who made their greatest gain during the winter season. (See Table 5).

Of the 23 children observed over a 2-year period, 14 made a greater gain in summer than in winter during both years. Of the remaining nine children, only two made a greater gain in winter than in summer, during both years. Twenty-one of the 23 children made a greater gain in summer than in winter during at least one of the 2 years.

TABLE 4.—Comparison of Average Monthly Gains for 173 Children Between the Summer and Winter Seasons

	First year—1927				Second year—1928				Third year—1929				3-year period—1927-1930			
	May-Oct.		Nov.-Apr.		May-Oct.		Nov.-Apr.		May-Oct.		Nov.-Apr.		May-Oct.		Nov.-Apr.	
	Lb.	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*
Entire group	0.48	67	0.24	33	0.56	56	0.44	44	0.47	61	0.30	39	0.49	60	0.32	40
Boys	0.52	75	0.17	25	0.56	58	0.41	42	0.50	59	0.35	41	0.52	62	0.32	38
Girls	0.43	57	0.32	43	0.56	54	0.47	46	0.42	64	0.24	36	0.45	58	0.32	42

TABLE 5.—Comparison of Number of Children Making Greatest Gain in Summer with Those Making Greatest Gain in Winter

Year	No. making greatest gain in summer	No. making greatest gain in winter
Entire group		
1927–28	35	9
1928–29	15	7
1929–30	35	13
Boys		
1927–28	20	2
1928–29	8	4
1929–30	20	7
Girls		
1927–28	15	7
1928–29	7	3
1929–30	15	6

This acceleration of growth in weight during the late summer and early fall is consistent with the findings of Malling-Hansen (16), Bleyer (3), Porter (23, 24), Gebhart (8), Orr (22), and of the Kansas study (12).

For the first year of the study, the boys averaged 75 per cent of their total yearly gain during the summer, as compared to a corresponding gain of 57 per cent for the girls. For the second year, the figures were 58 per cent for the boys, and 54 per cent for the girls. For the third year, however, the average percentage gain of the girls for the summer exceeded that of the boys, being 64 per cent, as compared to an average of 59 per cent for the boys.

Using the group of 114 children for whom complete records for one year or more were obtained, the percentage distribution between the two seasons was calculated for each child; for example, No. 4 gained 8.19 pounds during the second year, of which amount 4.31 pounds, or 52.6 per cent, were gained from May to October.

Another child, No. 35, with a yearly gain of 7.25 pounds, made 84.6 per cent of that gain during the summer. The average gains per season thus computed are recorded in Table 6. These averages vary slightly from the averages for the group of 173 children, but both show that more than one-half of the total annual increment in weight was made during the 6 months, May to October, inclusive.

It is interesting to note that 20 of the 29 children for whom winter increases in weight exceeded those for the summer season had been in nursery school during the winter months. Food and health habits of children are carefully supervised during the time

they are attending nursery school. The afternoon nap or rest is a part of the daily routine and shorter rests are taken at other times during the day. Three others of the 29 children were in a public school where a routine well adapted to the needs of the child is followed.

TABLE 6.—Average Percentage Distribution of Growth in Weight of 114 Children for the Summer and Winter Seasons Compared

	1st year, 1927-28		2nd year, 1928-29		3rd year, 1929-30		3-yr. period, 1927-30	
	May-Oct.	Nov.-Apr.	May-Oct.	Nov.-Apr.	May-Oct.	Nov.-Apr.	May-Oct.	Nov.-Apr.
Entire group	69	31	55	45	62	38	63	37
Boys.....	78	22	54	46	57	43	64	36
Girls.....	60	40	55	45	68	32	62	38

For these 20 children, afternoon naps were shortened or eliminated entirely during the summer. Hours of activity were thereby increased with resulting increased food requirements. According to the mothers' records, however, the amount of food eaten daily was approximately the same as that eaten daily during the winter months.

Two children lost weight during the summer season, but their losses were small, 1½ ounces for one child and 2 ounces for the other. Both children had been in nursery school during the winter. For one child, the mother's report showed that the afternoon nap was omitted and that the food habits were very irregular, with the food intake low during the summer months.

This same child had been observed the previous year and during that time had made a larger per cent of his yearly gain in the winter than in the summer. His food and health habits had been good during the first year of the study.

For the second child who lost weight during the summer months, the mother reported that the child's appetite was only fair.

The fact that 29 of the group of 114 children made their greatest gain during the winter season would seem to indicate that any advantage which may possibly be inherent in one season over another may be over-shadowed by environmental factors within the control of those who have the care of the child.

As compared to the two children who actually lost weight during the summer, there were seven children who lost weight during the winter; that is, they weighed less in April than they had weighed in October. Two of these children were ill during the winter; one had scarlet fever and the other had a skin eruption for

which a low fat diet was prescribed. With fat almost entirely absent from the diet, the calorie value of the food he was able to take was lower than the diet to which he was accustomed, and loss in weight was a natural outcome. These illustrations are cited to show some of the factors which may operate to retard a child's growth during any season.

For a group of Italian boys in New York, Gebhart reported a gain during August, September, October, and November of 55.3 per cent of the annual gain; that is, over half of the annual gain was made during a period comprising one-third of the year. During the same 4-month period, the girls of Gebhart's group made 59.8 per cent of their annual gain.

In the Ohio study, figures were obtained for every month of the year from May 1927 to May 1928. These figures are therefore available for comparison with the figures of Gebhart's study. For the Ohio boys, as for the New York boys, over half of the year's gain in weight was made during the third of the year from August to November, inclusive. The corresponding rate of increase in weight of the girls for the same period was somewhat smaller, being only 46 per cent, as compared to 59 per cent made by the boys. (See Table 7).

TABLE 7.—Comparison of the Gains in Weight of Gebhart's Group with the Ohio Group from August through November, 1927-1928

Month	Gebhart Boys		Ohio Boys		Gebhart Girls		Ohio Girls	
	Av. gain	Annual gain	Av. gain	Annual gain	Av. gain	Annual gain	Av. gain	Annual gain
	Lb.	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*	*Lb.*	*Pct.*
August	0.89	13.2	1.27	30.5	0.79	12.3	0.56	12.4
September	1.01	15.0	0.12	2.9	1.06	16.6	0.67	14.9
October	1.00	14.8	0.86	20.6	1.00	15.6	0.64	14.2
November	0.83	12.3	0.19	4.6	0.99	15.3	0.21	4.7

Porter (23, 24) made an extensive study of children in Boston and reported an indication of accelerated growth in the fall. Although the children included in the studies referred to above were older than the Ohio children, the same general trend toward seasonal variations is shown.

The change of weight in March and April among the Ohio boys showed the same tendency as that of the boys of Porter's study. Neither group was receiving nutritional care as were the Italian boys.

Seasonal variation occurred in all the groups of children included in the Kansas study (12). The light treatments which were started in the fall and the inclusion of oranges in the diets, also started in the fall, seemed to influence growth acceleration in the spring.

Orel (21) reported an increase in weight in October and November and a relatively low one in June and July with a certain periodicity.

Of the group of Ohio children for whom complete records were obtained for 1927 to 1928, only three children, or 7 per cent, showed either a steady gain in weight from month to month, or a stationary weight for not more than 2 consecutive months. These results compare very favorably with those obtained by Emerson with children in New York City, among whom only 6 per cent exhibited this phenomenon.

Loss of weight or arrest in gain is not unusual among children of school age according to Emerson (5), who states, ... "It is very common to find children in apparent health, holding the same weight for several months in succession, or actually lowering weight".

Actual gains as compared to expected gains.—The expected gains in weight for each group, as given by Holt (11), are shown in Table 8. Average annual gains for the children of each age group of the Ohio study are also shown for boys and for girls separately. With the exception of the girls from 4 to 5 years of age and the boys from 3 to 4, every group averaged a gain greater than the expected gain.

When the gains of individual children were compared with the expected gains however, the showing was not as favorable.

TABLE 8.—Comparison of the Average Annual Increase in Weight Suggested by Holt with the Actual Gains of the 114 Ohio Children

Age	Boys		Girls	
	Expected gain of Holt	Actual gain of Ohio children	Expected gain of Holt	Actual gain of Ohio children
Years	*Pounds*	*Pounds*	*Pounds*	*Pounds*
2-3	5.0	4.81	5.0	5.88
3-4	4.0	3.93	4.0	5.43
4-5	4.0	4.29	4.0	3.90
5-6	4.0	5.25	4.0	4.74
6-7	4.0	6.89	4.0	7.62
7-8	4.75	12.44	4.5	6.23

Only 52 per cent of the Ohio children made or exceeded the expected gain of Holt during the first year of the study. During the second year, 77 per cent and, during the third year, 62 per cent

of the Ohio children made or exceeded the expected gain of Holt. Of these children, the percentage of boys making or exceeding the expected gain was greater than that of the girls during the first and third years, as well as for the 3-year period. For the second year, the corresponding percentage was higher for the girls than for the boys. (See Table 9).

TABLE 9.—Number of Children Making the Average Annual Increase in Weight Suggested by Holt and Woodbury

Year	Entire group				Boys				Girls			
	Made or exceeded standard of Holt		Made or exceeded standard of Woodbury		Made or exceeded standard of Holt		Made or exceeded standard of Woodbury		Made or exceeded standard of Holt		Made or exceeded standard of Woodbury	
	No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
1927–1928.....	23	52	26	59	12	55	13	59	11	50	13	59
1928–1929.....	17	77	18	81	8	67	9	75	9	90	9	90
1929–1930.....	30	62	34	71	20	74	23	85	10	48	11	52
1927–1930.....	70	61	78	68	40	66	45	74	30	57	33	62

According to Holt, boys of 2 to 7 years of age should make the same annual gain in weight as girls of corresponding ages. This has not been the case among the Ohio children studied. During the first 2 years of the study, 1927 to 1929, the girls averaged a greater annual gain in weight than did the boys. During the third year, however, the situation was reversed, and the average annual gain of the boys exceeded the corresponding gains of the girls. Also, for the entire 3-year period, the increases in weight of the boys exceeded those of the girls. (See Table 3).

The Woodbury standard of expected gains, also based upon measurements of large numbers of children, is somewhat lower than that of Holt, but includes children from one to 6 years of age only (15). For the children from 6 to 8 years of age, figures of expected gain were compiled from the Baldwin-Wood tables (1). These standards of expected gain, compiled from the two sources mentioned above, are shown in Table 10. Comparison of actual gains with expected gains as given in the standard of Woodbury is also shown in Table 10.

For each of the age groups included in this study of Ohio children, the average actual gains for both boys and girls exceeded the expected gains. When the individual yearly gains of the children were compared with the corresponding expected gains, the situation was somewhat better than when the comparison was

made with the Holt standard. Fifty-nine per cent of the 114 children made or exceeded the expected gains of Woodbury during the first year; 81 per cent, during the second year; and, during the third year, 71 per cent made or exceeded the expected gains.

TABLE 10.—Comparison of the Average Annual Increase in Weight Suggested by Woodbury with the Actual Gains of the 114 Ohio Children

Age	Boys		Girls	
	Expected gain of Woodbury	Actual gain of Ohio children	Expected gain of Woodbury	Actual gain of Ohio children
Years	*Lb*	*Lb.*	*Lb.*	*Lb.*
2-3	4.3	4.81	4.5	5.88
3-4	3.6	3.93	3.7	5.43
4-5	3.6	4.29	3.6	3.90
5-6	3.6	5.25	4.0	4.74
6-7	4.0*	6.89	5.0*	7.62
7-8	5.0*	12.44	5.0*	6.23

*Taken from Baldwin-Wood standard for children of medium height (16).

During the first year of the study, the percentage of boys making or exceeding the expected gain was the same as the corresponding percentage for the girls; for the second year, the percentage of girls making or exceeding the expected gain was greater than that of the boys; whereas for the third year, the situation was reversed.

HEIGHT

From the individual gains of each of the 173 children, average monthly gains in height were calculated for the entire group, as well as for each sex. These averages for each of the 3 years, as well as for the 3-year period, are recorded in Table 11.

According to these figures, the late winter seems to be an unfavorable time for height increases. The February gains for boys, as well as for girls and for the entire group, are less than for any of the other months.

This month of lowest increase in height immediately precedes the 2 months of lowest increases in weight. As far as both height and weight gains are concerned, the late winter and early spring seem most unfavorable.

There is less uniformity as regards periods of rapid increases in height. For the boys, greatest gains in height were made in November; for the girls, the greatest gains in height were made in August.

As far as the relation of greatest increases in height to greatest gains in weight are concerned, there seems to be no special connection. In some cases greatest increases in weight precede greatest increases in height; in other cases, the situation is reversed.

TABLE 11.—Average Monthly Gains in Height of 173 Ohio Children

Year	May		June		July		August		September		October		November		December		January		February		March		April		Total
	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	Cases No.	Av. gain In.	In.
Entire group																									
1927–28...	44	0.24	44	0.39	44	0.28	44	0.32	44	0.15	44	0.19	44	0.19	44	0.25	44	0.20	44	0.18	44	0.21	44	0.23	2.83
1928–29...	30	0.22	30	0.24	30	0.24	30	0.24	30	0.24	36	0.24	36	0.17	36	0.20	36	0.30	35	0.13	34	0.25	30	0.24	2.71
1929–30...	73	0.22	62	0.22	60	0.23	60	0.23	60	0.23	74	0.25	75	0.32	69	0.23	67	0.18	71	0.16	71	0.22	71	0.20	2.69
1927–30...	147	0.23	136	0.28	134	0.25	134	0.26	134	0.21	154	0.23	155	0.25	149	0.23	147	0.22	150	0.16	149	0.23	145	0.22	2.77
Boys																									
1927–28...	22	0.23	22	0.41	22	0.29	22	0.27	22	0.11	22	0.21	22	0.19	22	0.28	22	0.21	22	0.15	22	0.24	22	0.21	2.80
1928–29...	17	0.19	17	0.23	17	0.24	17	0.23	17	0.24	18	0.30	18	0.20	18	0.22	18	0.33	18	0.07	17	0.28	15	0.31	2.84
1929–30...	38	0.24	30	0.21	30	0.23	30	0.23	30	0.23	40	0.22	40	0.34	39	0.23	40	0.17	40	0.17	39	0.20	38	0.22	2.69
1927–30...	77	0.23	69	0.22	69	0.25	69	0.24	69	0.19	80	0.24	80	0.27	79	0.24	80	0.22	80	0.14	68	0.23	65	0.23	2.70
Girls																									
1927–28...	22	0.24	22	0.38	22	0.28	22	0.38	22	0.19	22	0.17	22	0.19	22	0.23	22	0.19	22	0.21	22	0.18	22	0.26	2.90
1928–29...	13	0.26	13	0.25	13	0.25	13	0.25	13	0.25	18	0.18	18	0.13	18	0.18	18	0.27	17	0.19	17	0.23	15	0.17	2.61
1929–30...	35	0.20	32	0.22	30	0.23	30	0.24	30	0.24	34	0.28	35	0.29	30	0.23	27	0.20	31	0.15	32	0.25	33	0.18	2.71
1927–30...	70	0.22	67	0.28	65	0.25	65	0.29	65	0.22	74	0.22	75	0.22	70	0.22	67	0.22	70	0.18	71	0.22	70	0.20	2.74

Steady growth in height was more commonly the case among the children studied than was steady gain in weight. For the year 1927-28, 30 children showed a steady gain in height, or an arrest in height for not more than one month, as compared to three children who showed a steady gain in weight or an arrest in weight for no longer than one month.

In discussing the effects of malnutrition upon growth Roberts (25) says: "The upward impulse is so powerful in the young that growth in height may occur even when the body weight is stationary or declining . . . . . The skeleton increases in length at the expense of the other parts of the body, especially the muscles."

The distribution of increases in height between the summer season, May through October, and the winter season, November through April, was calculated, as was the distribution of increases in weight through the corresponding seasons. As with the average increases in weight, average increases in height were larger during the summer than during the winter season. The differences were so small, however, that they may possibly be considered fortuitous. For the 3-year period, the boys averaged 0.23 inch per month during the summer season, as compared with 0.22 inch per month during the winter season; for the girls, corresponding gains were 0.25 inch as compared with 0.21 inch; for the entire group, the figures were 0.24 inch as compared with 0.22 inch.

From his observation of school children in Honolulu, New York, and Toronto, Haven Emerson (5) says: "It is sufficient to record that no evidence was obtained suggesting that there is any seasonal variation in the gain in height of apparently healthy children among whom for one reason or another, irregularities in weight are common."

Actual gains in height as compared to expected gains.—Expected gains for children from 2 to 8 years of age as given by Holt are shown in Table 12. The average actual gains of the Ohio children of the study are also shown. Except for the boys of 3 to 4, the average actual gain is greater than the expected gain for both boys and girls.

When increases in height of individual children were considered, the proportion of children making or exceeding the expected gain in height was larger than the proportion of children making or exceeding the expected gain in weight. (See Table 13).

TABLE 12.—Comparison of Average Annual Gain in Height Suggested by Holt with Actual Gain of the 114 Ohio Children

Age	Boys		Girls	
	Expected gain of Holt	Actual gain of Ohio children	Expected gain of Holt	Actual gain of Ohio children
Years	*Inches*	*Inches*	*Inches*	*Inches*
2-3	3.5	3.52	3.5	3.59
3-4	3.0	2.66	3.0	3.02
4-5	2.5	2.64	2.5	2.55
5-6	2.0	2.54	2.0	2.73
6-7	2.0	2.38	2.0	2.50
7-8	2.0	3.12	2.0	2.12

For the entire group, 70, 77, and 75 per cent of the children made, or exceeded, the expected gain during the first, second, and third years of the study, respectively. For each year, as well as for the entire period, the percentage of girls making or exceeding the expected gain was larger than that of the boys.

TABLE 13.—Number of Children Making the Expected Gain in Height Suggested by Holt

Year	Entire group		Boys		Girls	
	Made or exceeded standard of Holt		Made or exceeded standard of Holt		Made or exceeded standard of Holt	
	No.	*Per cent*	*No.*	*Per cent*	*No.*	*Per cent*
1927-1928	31	70	15	68	16	73
1928-1929	17	77	7	58	10	100
1929-1930	36	75	20	74	16	76
1927-1930	84	74	42	69	42	79

FACTORS INFLUENCING GROWTH OF CHILDREN

FOOD HABITS

Since the importance of food as a factor in the growth of children is generally recognized, a fairly accurate record of the kind and approximate amounts of food eaten by each child was kept.

In studying the diet habits of children there are a number of items of special interest concerning individual foods and the frequency with which they are used.

Milk, eggs, vegetables other than potatoes, potatoes, fruits, and cereal products are valuable foods in the diet of the pre-school child. The nutritionist is interested in the amount of milk used daily, the kinds of fruits and vegetables used, as well as the frequency of their use, the frequency of using eggs, and the amount of cereal products in the diets.

Milk.—In estimating the adequacy of a child's diet the first food usually considered is milk. There is good reason for this emphasis. In experimental work with animals, as well as with children, the value of milk as a food for growth and health has been clearly demonstrated.

The importance of milk in the diet of children is stressed by Lyman (15) when he says:

> "Every one admits that milk is indispensable for infants, but there is a rather general belief that after the first year milk is no longer necessary, or at least that the amount of milk can be greatly reduced with safety. This is a great mistake. During the period of childhood, growth should go on steadily and rapidly. In order to secure this, the food of the child must be easily digested and rich in growth-producing materials, proteins, mineral salts, and vitamins. Milk is the only article of food that meets these requirements; in fact, a combination of any other foods cannot fully take the place of milk during this period of life.
>
> "A quart of milk a day for each child is a good and safe rule. Of course, milk should not be the only article of food, yet it should constitute the basis of the diet."

In discussing the results of the series of quantitative studies made by himself and Hawley on the balance of intake and output of calcium, Sherman (28) says:

> "Expressed merely in terms of quantity of calcium in the intake, these experiments show that for children of all ages from 3 to 13 years, inclusive, an average intake of not less than one gram of calcium per day (about twice as much as the maintenance requirement of an average man) is needed to support an optimum rate of storage in the normally growing child. But the experiments also show that better storage results when the calcium is furnished mainly in the form of milk, than when even one-half of the milk was replaced by vegetables of equal calcium content, even though the vegetables were selected and prepared with the greatest care to make them as suitable and as acceptable to the children as possible. Hence it seems better to state optimum intake not as such a weight of calcium merely but as a diet containing a full quart of milk a day, together with other foods suitable to the age of the child. Such a dietary will practically always contain one gram or more of calcium and a proportionally liberal amount of phosphorus as well as excellent protein and vitamin content."

Desirable as the daily quart of milk in the diet may be, most nutrition workers are satisfied if the child uses at least 1½ pints (three cups) daily. In estimating the adequacy of the diet of the children included in this study, the use of three cups of milk has been considered satisfactory.

Of the children of Group I, only four were reported as receiving less than three cups of milk daily. For the majority of the children of this group, then, the diets may be considered adequate as far as the use of milk is concerned.

The habit in regard to the use of milk was less satisfactory for the smaller group of children (Group II). Since these children averaged only about two cups of milk daily, their diets can hardly be considered satisfactory as far as milk is concerned.

For both groups of children, the amount of milk used did not vary with the seasons; that is, as much milk was used during the winter as during the summer.

Eggs.—For the young child, the quality as well as the quantity of protein in the diet is important. Eggs, as well as milk, are excellent sources of protein, calcium, and phosphorus, as well as vitamin A. The iron content of the egg is also high, an important consideration when milk forms a large part of the diet.

In studies with a group of young children, Rose (27) found that the addition of an egg a day to a diet which appeared to be adequate resulted in improvement in general health and in the hemoglobin content of the blood. Further work with eggs in the diet of rats showed the rate of growth of young rats having diets which seemed adequate otherwise but which were supplemented with an amount of egg equivalent to an egg a day in the diet of the young child was greater than that of young rats on diets not so supplemented. As Rose says, "The importance of milk and eggs as staple foods for the production of a vigorous race" is, therefore, shown.

Eggs formed a part of the diet of the children of Group I frequently. Served soft-cooked, poached, in omelet, or in other ways, eggs appeared in the diets on an average of four or more times a week. Among these children, eggs prepared in custard and puddings were also used frequently. The amount of egg used was practically the same from season to season.

Eggs appeared in the diets of Group II somewhat less often than in the diets of Group I. When used, eggs were frequently combined with other foods, as in souffles, puddings of various sorts, and in custards. For economic reasons eggs were used more frequently in the spring and summer months than during the winter when the cost was higher.

Vegetables.—Vegetables, other than potato, should be a part of the day's food of every child. It is important not only as a provision for present needs but as a matter of training in good dietary habits that children learn to eat and to like a good variety of these "protective foods".

The leafy vegetables are considered to have special dietary value. Mitchell (19) found that hemoglobin regeneration was rapid in rats given spinach in addition to other food. Green leaves are especially rich in vitamin A.

The use of green, leafy vegetables by the children of Group I seemed to be a well established habit and, moreover, the habit seemed not to be seasonal but one which prevailed during the entire year. Other vegetables, also, were used in fairly generous amounts by this group.

For the smaller group, neither the leafy vegetables nor other vegetables appeared in the diet in such variety or amount as was the case with the children of Group I, although a vegetable other than potato was used daily. There was a seasonal variation in the use of vegetables, by this small group, a greater variety, but not a greater quantity, being used during the summer than during the winter season.

Fruits.—Citrus fruit or tomato daily, in addition to cooked fruits, is considered desirable in the diet of young children. Working with a group of children, Newell and Miller (20) found an "unmistakable rise in the weight curves of underweight children, produced by the daily administration of 45 cubic centimeters of orange juice." This result may be "the effect of added vitamin A, B, or C, or of inorganic constituents which may either supplement a deficiency of these substances or produce some other change such as a shift in the acid-base equilibrium."

Chaney and Blunt (4) observed an increase in calcium, phosphorus, magnesium, and nitrogen retention and a marked increase in weight of two children when orange juice was added to their diets.

The addition of orange juice to the diets of the children in the Kansas study was thought to have influenced their seasonal variation in growth (12).

The majority of the children of Group I attended nursery school or kindergarten where they were given orange or tomato juice as part of the daily school routine. In many cases the children were given either oranges or tomatoes at home also, so that for these children the provision of a citrus fruit or tomato juice was the accepted routine. This custom varied little with the seasons, being followed in winter as well as in summer. In addition, some cooked fruit, such as apples, pears, peaches, or prunes, was used at least once daily and sometimes more frequently. As

far as the use of fruits, both cooked and raw, is concerned, the food habits of Group I were excellent and seemingly varied little from season to season.

For Group II, the custom in regard to fruit was less desirable. It was used less frequently than was the case with Group I. In addition, more of a seasonal variation in the use of fruit was evident.

Cereals.—For both groups the use of cereal products was a well established habit. In low cost diets, such as were used by the children of Group II, it is usually necessary to use cereals in liberal amounts. Care must then be taken in the choice of cereals, whole rather than highly milled products being desirable. In addition, supplementary foods must be chosen carefully if the diet is to be adequate.

Adequacy of the diets.—Because the large amount of cereals in the diets of the children of Group II was supplemented with less than the desirable three cups of milk daily and because fruits and vegetables were used somewhat sparingly, it is not surprising that the diets of the children of this group were graded lower in a scale of adequacy than were the diets of Group I.

The children of Group I, whose diets were considered fully adequate from the standpoint of the use of what might be termed "foundation foods", made an average yearly gain in height of 2.75 inches and in weight of 5.07 pounds. The children in Group II, whose diets were considered only fairly adequate, made an average yearly gain in height of 2.50 inches and in weight of 3.63 pounds; that is, the children of Group I gained 7 per cent more in height and 40 per cent more in weight than did the children of Group II.

Each group of children averaged the expected gain in height and weight. The increased gain in both height and weight of the children of Group I over corresponding increases made by the children of Group II would seem to indicate that although children may make the expected gain on diets which seem to be fairly adequate, an improvement in diet may accelerate growth. There seems to be little doubt that the quantity and quality of food influences the rate of growth.

As far as kinds and amounts of foods used are concerned, especially with the larger group of children, Group I, there appeared so little change in food habits from season to season that it seems impossible to attribute the increased rate of growth during the summer season to increased food intake.

The quality of food, however, may vary from season to season. According to Bethke, et al. (2), the fat-soluble vitamin content of hen's egg yolk depends upon environment and diet. They summarize their results as follows:

> "The fat-soluble vitamin content of egg yolk is greatly influenced by the amount of these substances present in the ration and by the environment of the laying hen.
>
> "Yolks of eggs laid by hens which had access to a blue grass range were approximately 5 times as potent in vitamin A and 10 times as active antirachitically as the yolks of eggs laid by hens which received the same basal mash but were confined indoors."

In a study of the antirachitic properties of dry milk, Supples and Dow (30) report the following results:

> "Summer-produced and winter-produced dry milk, made by the Just double cylinder process tested for antirachitic and calcifying properties under identical conditions, showed that the summer-produced milk possessed greater antirachitic and calcifying properties than the winter-produced milk."

Krauss and Hunt (13), of the Ohio Agricultural Experiment Station, report an increased vitamin content of milk produced by cows on summer pasture over the vitamin content of milk produced by the same cows when kept indoors.

Fresh, summer-grown spinach has also been shown to have definite, if slight, antirachitic value; whereas the winter-grown spinach had no effect (29).

In commenting on the acceleration of growth in the summer months, Lusk (14) says, "Sunshine in the air and the green things in the food of the summer months are great gifts."

Since milk and eggs, as well as green vegetables, were used by both groups, the improved quality of these foods during the summer may have influenced the seasonal rate of growth.

HEALTH HABITS

The hours of rest during the day seemed to vary more with the different ages than with the seasons of the year. In her observations of pre-school children in South Carolina, Frayser (7) says, "The day time naps were nearly all taken by children one, two, and three years old, naps diminishing as ages studied advanced."

Discontinuing the afternoon nap gives children more time for activity and, hence, a need for larger food intake to meet this demand. One reason for the small gains for some of the Ohio children studied may be that the food intake did not adequately meet the needs for growth, activity, and basal metabolism. Rose

(26) says, "It must be constantly borne in mind that storage in growth is only possible when the basal energy requirement and the additional calories needed for activity have been met."

The majority of the Ohio children observed the second and third years attended a nursery school or kindergarten at least part of the time during the period from about October first to June first.

The regular routine of rest and play and the careful supervision of food in these schools may be factors in explaining the greater average growth of the children observed during these 2 years, as compared to the growth of the children observed during the first year.

The regularity of routine, with emphasis upon the rest periods, may also account for the fact that seasonal variations in weight were less evident during the second and third years than during the first year of the study when fewer of the children were attending nursery school or kindergarten.

No record of activity was made but the relation of the amount of activity and the food intake to the rate of growth offers a suggestion for study.

SUNSHINE AND HOURS SPENT OUT-OF-DOORS

Among the factors other than those already discussed (that is, the quantity and quality of food and the hours of rest) might be added the effect of sunshine. Much importance is attached to the value of the ultra-violet light. These rays constitute less than one per cent of the total solar radiations. They have little power of penetration and may be absorbed by smoke and dust in the air.

There is also a difference in the effectiveness of the ultra-violet rays at different seasons. Hess (9) says, "It would seem that the amount of the effective solar radiations is so small in the winter, that even if we substitute quartz panes for ordinary window glass, it will be insufficient to afford protection and eradicate rickets."

In a study made by Tisdall and Brown (31) on the antirachitic effect of the sun's rays in Toronto, they say, "The antirachitic effect of sunshine during April, May, June, July and August is approximately eight times as great as during November, December and January."

Because of the value of the ultra-violet and its variations with the seasons, it was thought that the number of hours spent out-of-doors might suggest a possible cause of acceleration or retardation of growth of the children of the Ohio study. The records show that the number of hours spent out-of-doors varies greatly from

season to season. Every child spent more time out-of-doors during the summer than during the winter, the average for the summer being from 6 to 12 hours, as compared to a winter average of from ½ to 3 hours.

Figure 1 shows the seasonal variation in the ultra-violet of the sun during 1927 in Manhattan, Kansas. The season of most rapid growth for the Ohio children parallels closely the season when the ultra-violet rays were most abundant in Kansas. The children were not only spending more hours out-of-doors during the summer months, but the value of the sunshine during these months was greater than during the winter months.

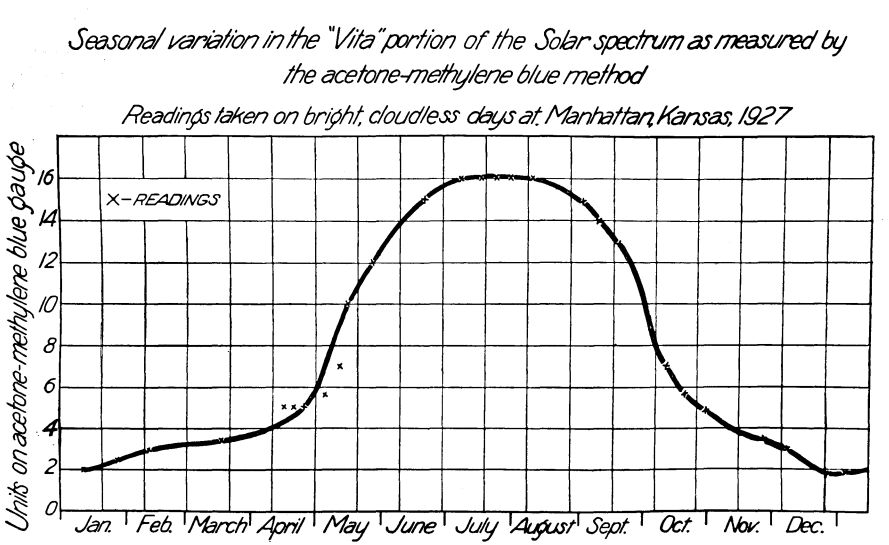

Figure 1.*

The time spent out-of-doors by the children of Group I was not only in excess of that spent out-of-doors by the children of Group II but was characterized by greater freedom. Free play in the open is probably an important factor in growth. Roberts (25) names the lack of outdoor play as one of the causes of malnutrition. She says it is not easy to explain how indoor housing affects nutrition but that, nevertheless, sunshine, fresh outdoor air, and wholesome happy play are absolute necessities for sound development.

PREVALENCE OF ILLNESS

Because of the relatively long intervals between weighings it is impossible to state definitely the effect of illness upon growth. There are instances where loss of weight was accompanied by, or

*Courtesy of Dr. J. S. Hughes, Department of Chemistry, Kansas State Agricultural College.

followed, illness, but there were other cases where there was no loss of weight in case of illness, or there was a loss of weight when the child appeared to be well.

There is the possibility that the relation of the illness to the time of weighing may be responsible for the varied results; for example, a child may have been weighed immediately following an illness and another may not have been weighed until 3 weeks after recovery. In the latter case, he may have had time to gain any weight that might have been lost during the illness, and also some weight in addition.

No child of the group suffered from any serious illness, but practically all the children were ill at some time during the period of the study. Measles, chicken pox, mumps, whooping cough, influenza, colds, bronchitis, and laryngitis were some of the illnesses reported by the mothers. One child had a broken arm and several had tonsilectomies.

The percentage of illnesses among the children comprising the group studied in 1927 was larger than corresponding percentages for either of the other 2 years, and the average gain in weight was less.

March and April of that year were especially characterized by the large number of cases of illness. These 2 months were also the ones of minimum gain in weight and of only average gain in height for the year.

There were only four of the children who were not ill at some time during the year 1927. Three of the four made a greater gain in both height and weight than the average of the group for the year. All four made a larger per cent of the annual gain in weight during the summer than during the winter, not differing in this respect from the children who were ill at some time during the year.

As previously stated Orel (21) accounts for the increase in weight during October and November by the relative infrequency of disease in the autumn. Emerson (5) found 4.5 times as many cases of illness in the winter as in the summer. He says, "It will be noted that there are 6.6 times as many instances (160:24) of loss of weight or arrest of weight connected with reported illness in the 5 months, January to May, as there are in the 5 months July to November."

WEATHER CONDITIONS

SUNLIGHT, TEMPERATURE, AND HUMIDITY

The average number of hours of sunshine per month, the average mean temperature, and the average rainfall per month for each of the two seasons for each year of the study were compiled from the report of the United States Department of Agriculture Weather Bureau, Columbus, Ohio. These data are shown in Table 14. The averages show more than twice as many hours of sunshine during the summer as in the winter.

It is of interest, also, to note that during the summer the total hours of sunshine were from 60 to 65 per cent of the possible number of hours of sunshine, while in the winter they were only 36 to 39 per cent of the total number possible; that is, during the winter months, only about 2 days out of 5 were sunshiny.

Practically every child was allowed to play out-of-doors during the winter when the weather was favorable. As cited in the section on Health Habits, the amount of ultra-violet during this season is small. The children, therefore, did not have the beneficial effects of the abundant ultra-violet which characterizes the summer season.

The average mean temperature for the summer months was 66.1° F. for the first year, 66.2° F. for the second year, and 68.1° F. for the third. For the winter months, an average temperature of 37.8° F. was recorded for the first year, 39.4° F. for the second year, and 39.2° F. for the third year.

In most instances, except in cases of extreme cold, the children were allowed to play out-of-doors, regardless of temperature.

TABLE 14.—Seasonal Averages of Hours of Sunshine, Temperature, and Humidity

	Av. total sunshine hours per month—summer season	Av. total sunshine hours per month—winter season	Av. mean temperature per month—summer season	Av. mean temperature per month—winter season	Av. rainfall per month—summer season	Av. rainfall per month—winter season
1927–1928.....	268.8	130.6	66.1	37.8	3.19	3.20
1928–1929.....	253.8	129.9	66.2	39.4	3.24	3.79
1929–1930.....	255.1	123.0	68.1	39.2	1.86	3.21

Orel attaches some importance to the factor of temperature in the rate of growth of children. According to his report, the increased loss of body moisture in the summer is not covered by a sufficient intake. In the first year of this study, the month of July

was one of the 3 months of minimum gain in weight. It was also the month of highest mean temperature, as well as of the maximum temperature, of that year. Loss of body temperature may possibly account for the low weights recorded for the children during this month.

The average rainfall for the two seasons was practically equal in the first 2 years but the rainfall during the winter season of the third year was about three-fourths greater than during the summer season of the same year. It will be remembered that this was the time of the drouth, the summer of 1930.

SUMMARY AND CONCLUSIONS

Procedure.—A study of seasonal variations in the growth of pre-school children has been carried on over a period of 3 years. During this period, twenty-three children were weighed and measured for 2 years at monthly intervals except during the summer. For 68 other children, monthly records were obtained for one year, making a total of 114 records which are complete for one year. For 59 other children, records were obtained for periods varying from 2 to 11 months.

Information concerning food and health habits and the general health of each child was obtained from the mothers, or others, in charge of the child.

The monthly gain or loss in weight was calculated for each child. The yearly increment in pounds was calculated for each child for whom a complete yearly record was obtained. The average monthly gain in weight was calculated separately for boys and girls and for the entire group. For the purpose of this study, the year was divided into two seasons; May to October, inclusive, was termed the summer season and November to April, inclusive, the winter season. The averages for the two seasons were made and compared. The annual increments in weight were compared with the expected gains suggested by Holt and Woodbury.

The data concerning the monthly gains in height were treated as those of weight. The yearly gains in height were compared with the expected gains of Holt.

The food habits of the members of the group were studied. A comparison was made between the quantity and quality of food and the rate of growth.

Health habits, such as hours of rest and hours out-of-doors, in the two seasons were compared.

The report of the United States Weather Bureau, Columbus, Ohio, was summarized as to temperature, humidity, and hours of sunshine for the two seasons.

The prevalence of diseases among the children of this group and the relation to the seasons were noted.

Findings and conclusions.—I. There was little variation from season to season in the foods used by the majority of the children. The quality of the food in the summer may be more conducive to growth than the quality of the winter food.

A small group of 14 children were receiving diets which were not quite as good as those of the remaining children. Those receiving the better diets gained at a greater rate in both height and weight.

II. Hours out-of-doors varied with the seasons; more hours were spent out-of-doors during the summer than during the winter. Determinations of the ultra-violet of the sun's rays at different seasons of the year have shown that the ultra-violet rays are more abundant and of greater intensity in the summer than in winter.

Fresh air and free play out-of-doors, as well as the increased amount of ultra-violet. are undoubtedly factors that influence the rate of growth.

III. Among the children studied, illnesses were more prevalent during the winter than during the summer. The period when illnesses were most frequent, March and April 1927, was the period of least increase in weight.

IV. There is a decided tendency toward a seasonal variation in the rate of growth in weight of pre-school children, the period of most rapid growth being in the late summer and early fall, with the period of minimum gain in the winter and spring.

Seasonal variations in increases in height were so small as to be insignificant. This may indicate that as far as increases in height are concerned environment is less of a factor than is the case with increases in weight. In other words, the less favorable environment of winter does not depress the impulse of growth upward as it depresses increases in weight. From this it may be reasoned that with environmental conditions as good in winter as in summer, the rate of growth during the winter season would be equal to that of the summer season.

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